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in Entry-Deterrence

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by Lanny Arvan*

Abstract

In this note it is argued that post-entry should be distinguished from pre-entry by the incurrence of capacity costs on the part of the entrant rather than by the incurrence of set-up charges, as is done in Dixit (1980). That is, capacity costs should be thought of as fixed costs for both incumbent and entrant and set-up charges are linked to the decision whether to produce or not, but not to the purchase of capacity. With this approach there is the possibility of multiple equilibria in Dixit's model, as is described in Dixit (1974). By viewing the pre-entry capacity commitment and the post-entry play as different stages of an extensive form game, as is done in Spulber (1981), we examine which of these equilibria is perfect. It is shown that multiple perfect equilibria are possible.

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A Note on the Role of Investment in Entry-Deterrence

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I. Introduction

Dixit (1980) analyzes a post-entry and pre-entry duopoly game when an incumbent firm can make a prior capacity commitment and both entrant and incumbent face declining average production costs in the form of fixed set-up charges. As a consequence of the declining average costs, there is a limiting output level by the incumbent at which the entrant's best response yields the entrant zero profit. When the incumbent firm is committed to this output level the entrant is indifferent between entering or not but, were it to enter under these circumstances, it would do so at an output bounded away from zero. Dixit poses the following two questions. When is a prior commitment by the incumbent to a capacity level larger than the limiting output equivalent to a commitment to produce beyond the limiting output? If this equivalence holds, when does the incumbent prefer to limit entry and when would it rather accommodate entry?

In a related paper, Dixit (1979) has shown that in a static duopoly model where both firms face declining average cost curves, there can be multiple Cournot equilibria. The monopoly output will yield a Cournot equilibrium if the monopoly output is greater than the limiting output. Under the identical cost and demand conditions there can also be the standard Cournot equilibrium with both firms producing positive amounts. Yet in Dixit (1980), though market conditions satisfy the assumptions of the 1979 paper, this multiplicity does not

arise. In this note it will be shown that Dixit discarded a potential equilibrium in his analysis, i.e., one must confront the multiple equilibria issue in general. One way of doing so is to recast the model in extensive form, as in Spulber (1981), and then employ a more restrictive solution concept to eliminate this multiplicity. In this context, perfect equilibrium would seem to be the appropriate concept.

In deciding on the appropriate extensive form game the critical question is whether it is proper to view capacity costs as part of entrant marginal cost in the post-entry game. In this paper, we adopt the point of view that post-entry is distinguished from pre-entry by the incurrence of capacity costs on the part of the entrant. Hence, in the post-entry game capacity costs do not enter into the marginal cost calculation. This approach differs from that of Dixit who distinguishes post-entry from pre-entry by the incurrence of set-up costs. To justify our approach we cite Dixit [1980, p. 96]

I shall reduce the dynamic aspects to the barest essentials by ignoring all lags. Either entry does not occur at all, in which case the established firm continues in a stationary state, or else it occurs at once, and the post-entry equilibrium is also established at once, so that the resulting duopoly continues in its stationary state. It is as if the two players see through the whole problem and implement the solution immediately...

In the stationary, post-entry duopoly, capacity costs are fixed rather than variable costs because, according to Dixit,

The established firm chooses a pre-entry capacity level k_1 . This may subsequently be increased, but cannot be reduced...

In all periods subsequent to the period of entry the entrant is also an established firm. Hence, it should treat Dixit's constraint in the

same manner as the incumbent firm. Dixit's formal model, which has capacity costs in the entrant marginal cost calculation, is really an examination of in and out entry rather than the stationary, post-entry duopoly that it purports to be.

The results of this paper show that when there is a unique perfect equilibrium of the extensive form game, the conclusions of Dixit (1980) still hold, i.e., the discarded equilibrium is not perfect. However, it is possible for there to be multiple perfect equilibria. We demonstrate when this is the case. The presence of multiple perfect equilibria leaves open the question concerning the equivalence of a prior capacity commitment to a commitment to produce beyond the limiting output level.

II. The Model and Results

We assume the identical cost and revenue functions posited by Dixit (1980). Let the subscript 1 denote the established firm and 2 the prospective entrant. If firm i has capacity k_i and is producing output x_i (with $x_i \leq k_i$), its costs per period will be

$$(1) \quad \begin{aligned} C_i &= f_i + w_i x_i + r_i k_i & \text{if } x_i > 0 \\ &= 0 & \text{if } x_i = 0 \end{aligned}$$

where f_i is the fixed set-up cost, r_i the constant cost per unit of capacity, and w_i the constant average variable cost for output.

The revenues per period for the two firms will be functions $R^i(x_1, x_2)$. The following properties are assumed to hold

$$(2) \quad R_i^i > 0, R_{ii}^i < 0, \text{ and } R_j^i < 0 \text{ for } i, j = 1, 2 \text{ and } i \neq j,$$

$$\text{and } R^1(0, x_2) = R^2(x_1, 0) = 0.$$

In the absence of prior capacity, profits of firm i are given by

$$(3) \quad \begin{aligned} \pi_i(x_1, x_2) &= R^i(x_1, x_2) - f_i - (w_i + r_i)x_i & \text{if } x_i > 0 \\ &= 0 & \text{if } x_i = 0. \end{aligned}$$

With prior capacity, k_i , profits of firm i are given by

$$(3') \quad \begin{aligned} \pi_i(x_1, x_2, k_i) &= R^i(x_1, x_2) - f_i - w_i x_i - r_i \max(k_i, x_i) & \text{if } x_i > 0 \\ &= -r_i k_i & \text{if } x_i = 0. \end{aligned}$$

In Figure 1 (Figure 1 is a reproduction of Figure 3, Dixit [1980, p. 99]), MM' and RR' represent the static reaction function for Firms 1 and 2 respectively, when capacity costs are included in marginal costs and start-up costs are ignored. NN' is the static reaction function for Firm 1 when capacity costs and start-up costs are ignored. When start-up costs are present there is a point on RR' , call it B , $B = (B_1, B_2)$, such that $\pi_2(B)$, the profits of Firm 2 at the joint output vector B , equals 0. B_1 is the limiting output by Firm 1. For any output by Firm 1 greater than B_1 , Firm 2 would rather make zero profits by not entering than choose the output that would put it on RR' .

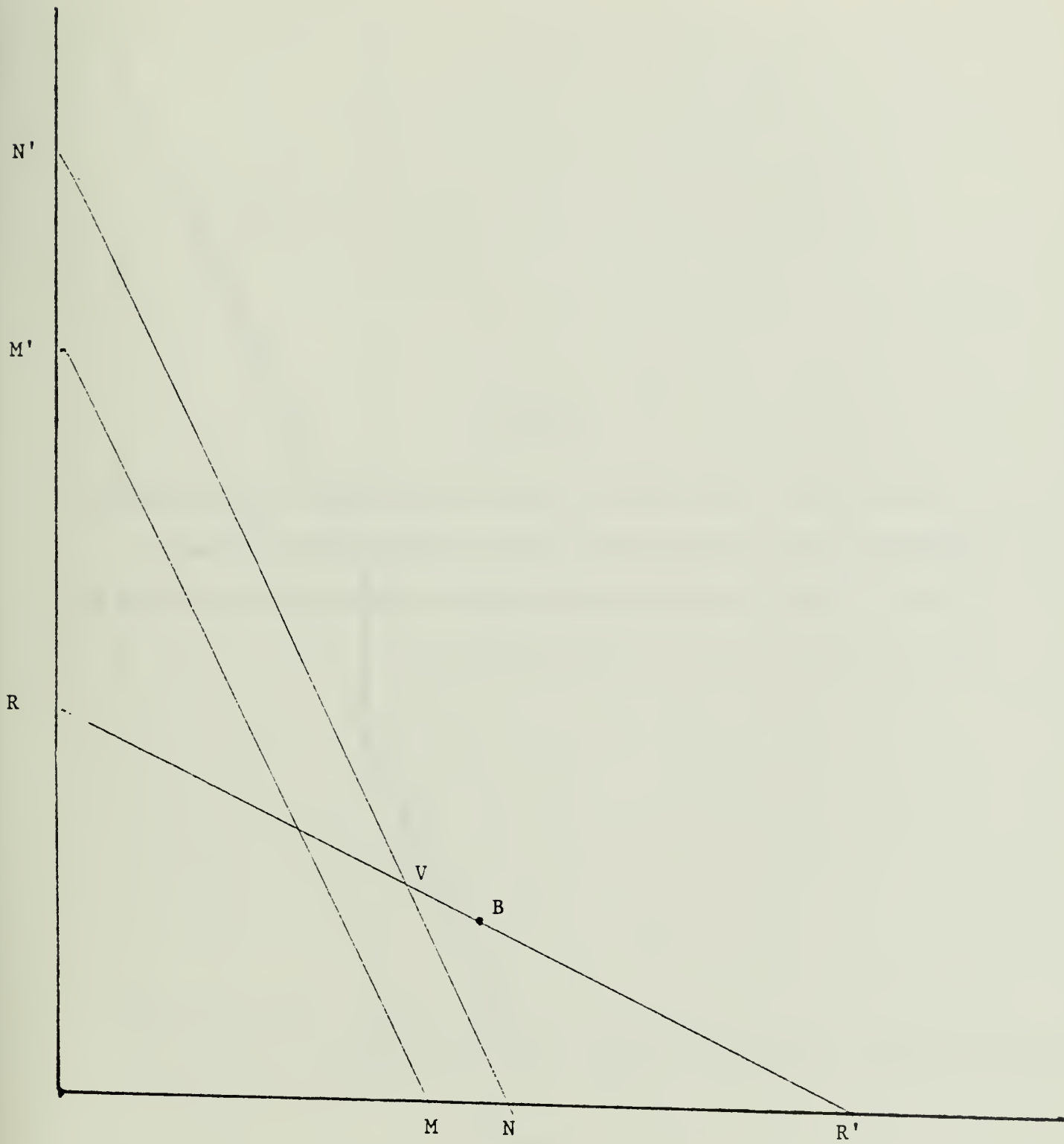


Figure 1

Figure 1

Since Firm 1 makes a prior capacity commitment of k_1 its reaction function is given by the kinked curve in Figure 2 shown in heavy lines. In what follows we do not concern ourselves with the effect of start-up costs on Firm 1's output decision.

Figure 2

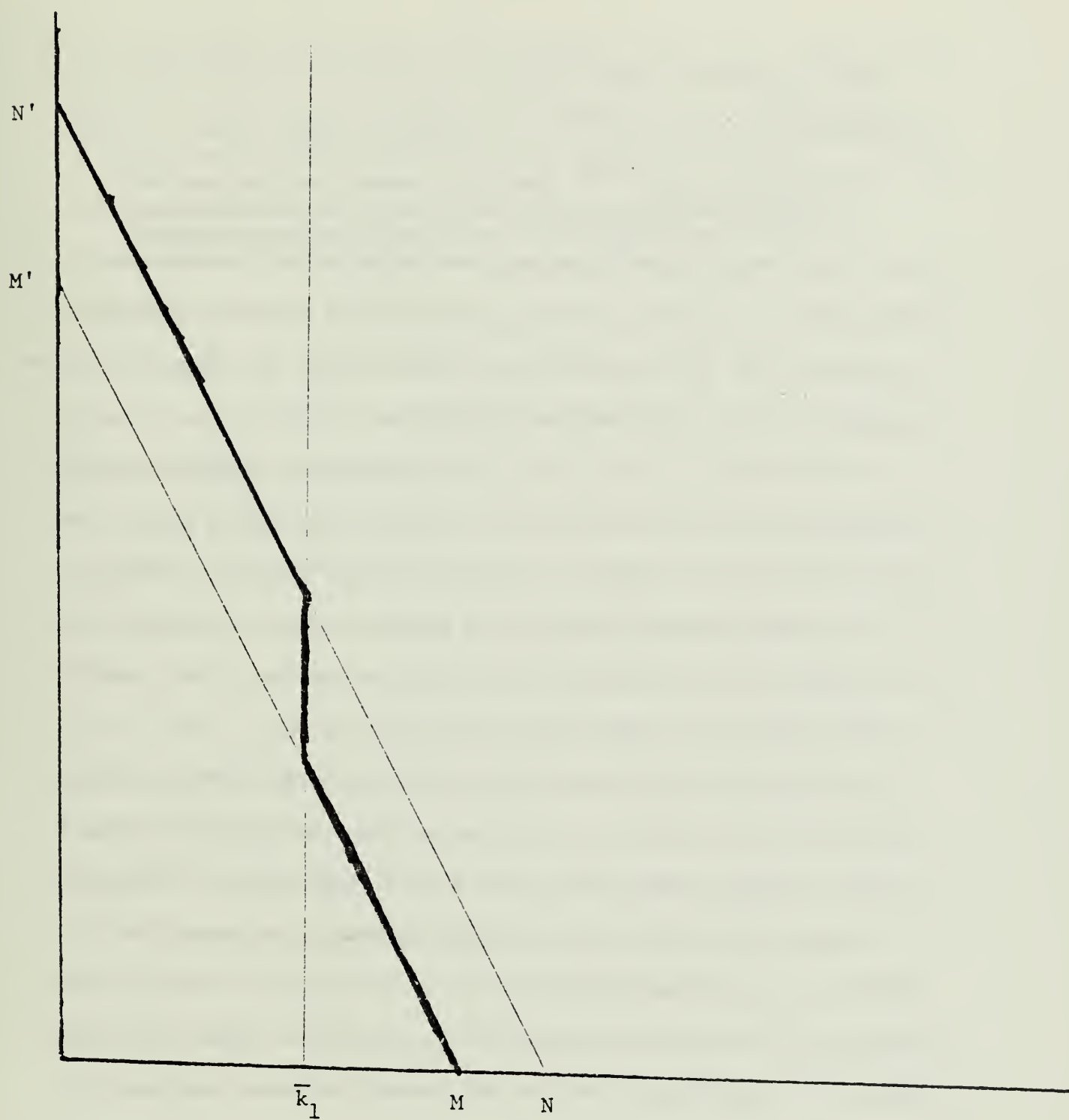


Figure 2

Dixit apparently claims that when $\pi_2(V) > 0$, V is the only Nash equilibrium as long as $\bar{k}_1 \geq V_1$. According to Dixit [1980, p. 100]

Case 2. $\pi_2(V) > 0$. Here the prospective entrant will make a positive profit in any post entry equilibrium so the established firm cannot hope to prevent entry. It can only seek the best available duopoly position...

When $\pi_2(V) > 0$, $B_1 > V_1$. When $B_1 > N_1$ Dixit is correct. But when $V_1 < B_1 \leq N_1$ and $\bar{k}_1 > B_1$ there is a limiting Nash equilibrium, just as in Dixit (1979). This limiting equilibrium is where $x_1 = \min[\max(\bar{k}_1, M_1), N_1]$ and $x_2 = 0$. Suppose the limiting equilibrium prevails over the equilibrium V when $B_1 < \bar{k}_1$ and $B_1 \leq N_1$. One must still resolve whether it is preferable for Firm 1 to choose $\bar{k}_1 > B_1$. Note however, that in some instances this is obvious as it is possible for $M_1 > B_1 > V_1$. By Dixit's own arguments it is conceivable that Firm 1 limits even when $\pi_2(V) > 0$.

As discussed in the introduction, the above equilibrium really addresses the situation where the entrant is around for only one period. One might reasonably ask the following question. Suppose Firm 2 does enter, even if this entails losses. How does Firm 1 respond to this entry? This question cannot be solved by pure static analysis. Spulber (1981) solves this problem when post-entry duopoly lasts for one period. Through a small modification in his model we can interpret this solution as Dixit wishes us to; the post-entry duopoly continues in a stationary state. In addition, we include the start-up costs that are not included in Spulber's analysis.

Our extensive form game occurs in three stages. In the first stage Firm 1 acts as a monopolist and purchases capacity, $\bar{k}_1$. This first stage is identical to the first period of Spulber's model. In

the second stage the entrant can purchase capacity, $\bar{k}_2$. There is no production in the second stage. This stage can be thought of as occurring between the first and second period in Spulber's model. In the third stage Firms 1 and 2 have prior capacity of $\bar{k}_1$ and $\bar{k}_2$ respectively. Both firms can buy additional capacity if they wish in this stage and both firms are Nash quantity setters in their respective outputs. We first look at the equilibrium in the third stage given $\bar{k}_1$ and $\bar{k}_2$. This equilibrium can be thought of as a stationary state in the post-entry duopoly.

Firm 1's reaction function for this third stage game is given in Figure 2. However, Firm 2's reaction function is no longer given by RR' to the left of B. Instead it is given by the kinked curve in Figure 3 shown in heavy lines. As $\bar{k}_2$ has already been chosen in the second stage, capacity costs do not enter into the marginal cost calculations for Firm 2 until its output reaches the prior capacity, $\bar{k}_2$. However, since set-up charges are still incurred in the third stage, when output is positive, Firm 2 might still find it advantageous to produce nothing in the third stage to avoid the set-up charges. Hence, there is a point, L, on Firm 2's reaction function such that $\pi_2(L, \bar{k}_2) + r\bar{k}_2 = 0$. Since the fixed capacity costs do not enter into the decision whether to produce in the third stage, it is evident that $L_1 \geq B_1$.

Figure 3

Suppose $\pi_2(V) > 0$, $\bar{k}_1 > B_1$, and $\bar{k}_2 = V_2$. There are two cases to consider in understanding equilibrium of the third stage game. The first is when $L_1 > N_1$. Then the only equilibrium in this stage is at V . The second possibility is $B_1 \leq L_1 \leq N_1$. Then for $\bar{k}_1 > L_1$ there is a limiting equilibrium in the third stage. There is still the equilibrium at V . If for $\bar{k}_1 \geq V_1$, $\bar{k}_2 \geq V_2$, V is the unique equilibrium of the third stage game, the limiting equilibrium of the extensive form game is not perfect. However, when there are multiple equilibria of the third stage game there can be multiple perfect equilibria. In the first equilibrium, Firm 1 acts on its "rational belief" in stage one that if it purchases capacity greater than L_1 , it will keep Firm 2 out. In the second equilibrium, Firm 1 acts on the rational belief that it can never keep Firm 2 out. Note that even with the first type

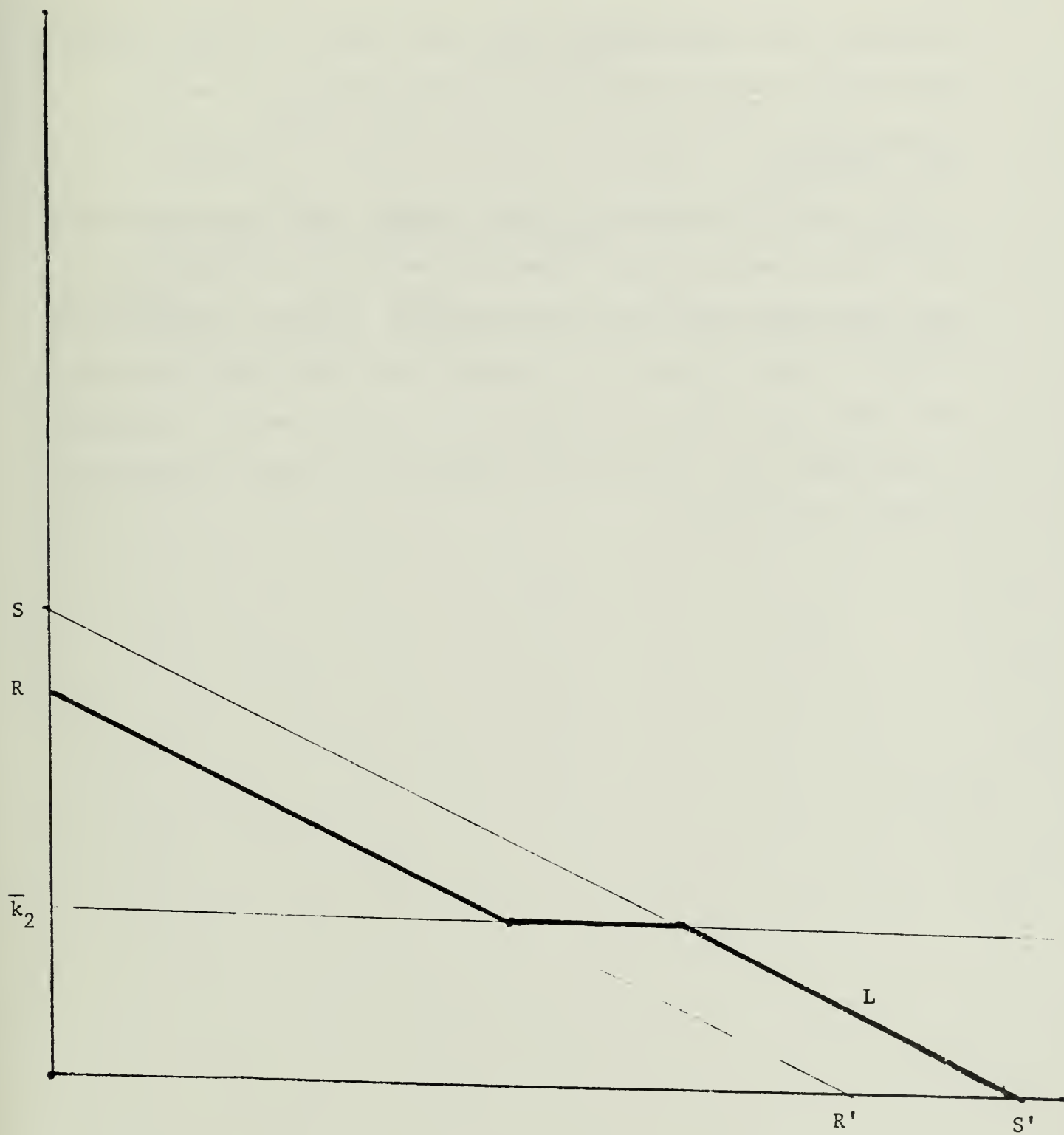


Figure 3

of beliefs, Firm 1 may choose $\bar{k}_1 < L_1$, i.e., there is a unique perfect equilibrium. This will happen when limiting entry is too costly.

III. Conclusion

The results of the previous section suggest that whether capacity is a credible entry deterrent depends on the beliefs of firms as to which Nash equilibrium will arise post-entry. It seems reasonable then to look at other actions by the incumbent, aside from capacity investment, which might affect the beliefs of a potential entrant. Expansion of the formal model to include the possibility of other actions may be helpful in this regard.

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